



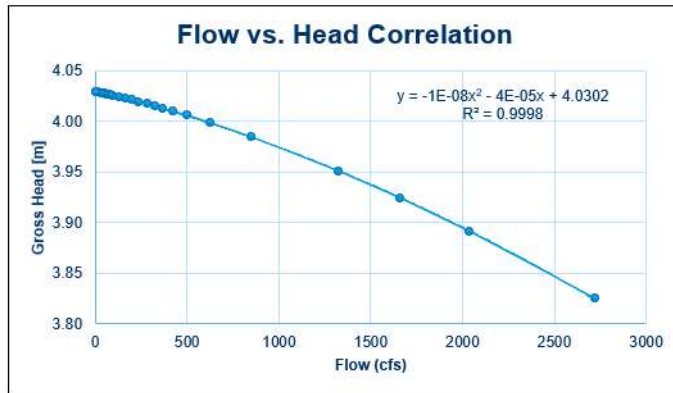
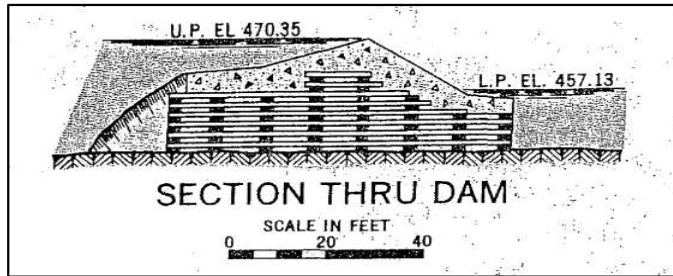
100% UPDATE: HYDROPOWER COLLEGIATE COMPETITION

March 28th, 2024

Riley Frisell
Evan Higgins
Trevor Senior

STREAMDIVER SIZING – ASSUMING HEAD

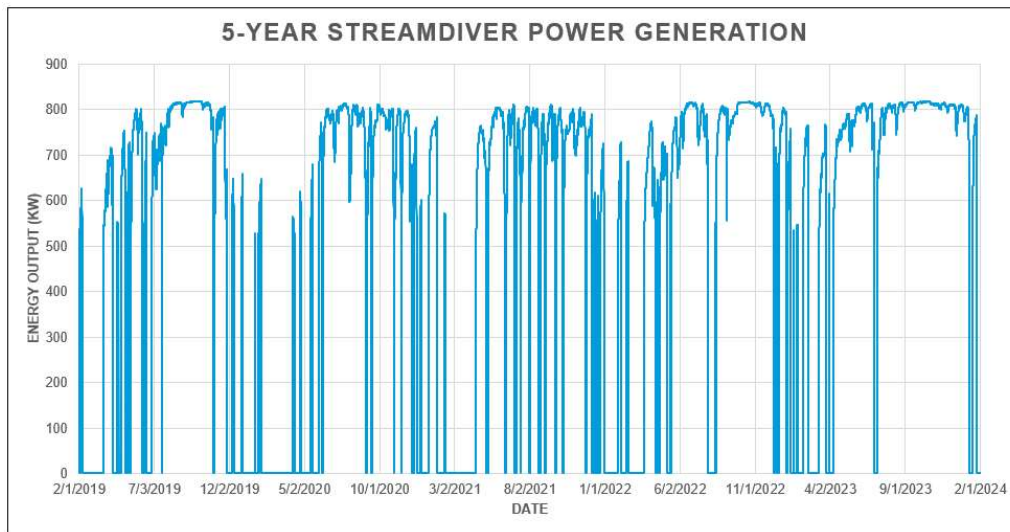
- **Assume:** At hydraulic height of 13.22 feet, the flow is 0 cfs
- **Assume:** Polynomial trendline related to USGS gauge height and flow



Days [d]	Flow [cfs]	Gross Head [ft]	16.95 Unit Output and Production		10.15 Unit Output and Production		Total Output and Production		
			[kW]	[MWh]	[kW]	[MWh]	[kW]	[MWh]	
0.365	2720.2	12.55	0	0	0	0	0	0	
3.285	2034.3	12.77	0	0	0	0	0	0	
5.475	1656.5	12.87	0	0	0	0	0	0	
9.125	1319.6	12.96	0	0	0	0	0	0	
18.25	846.7	13.07	0	0	0	0	0	0	
18.25	625.8	13.12	600	262.8	211	92.61	811	355	
18.25	498.4	13.14	601	263.4	212	92.84	813	356	
18.25	419.1	13.16	602	263.8	212	92.97	815	357	
18.25	368.1	13.17	603	264.1	212	93.05	815	357	
18.25	322.8	13.17	603	264.3	213	93.13	816	357	
18.25	282	13.18	604	264.5	213	93.19	817	358	
18.25	236.2	13.19	604	264.7	213	93.26	817	358	
18.25	194.8	13.19	605	264.8	213	93.31	818	358	
18.25	162.8	13.20	605	265.0	213	93.36	818	358	
18.25	128.6	13.20	605	265.1	213	93.40	818	358	
18.25	95.4	13.21	605	265.2	213	93.44	819	359	
18.25	78.7	13.21	606	265.3	213	93.46	819	359	
18.25	61.7	13.21	606	265.3	213	93.48	819	359	
18.25	50.1	13.21	606	265.4	213	93.50	819	359	
18.25	38.8	13.22	606	265.4	213	93.51	819	359	
18.25	27.3	13.22	606	265.4	214	93.52	820	359	
18.25	12.9	13.22	0	0	214	93.54	214	94	
9.125	7.3	13.22	0	0	214	46.77	214	47	
5.475	3.4	13.22	0	0	214	28.06	214	28	
3.285	2.6	13.22	0	0	214	16.84	214	17	
							Total Annual Generation (MWh)	5912	
							Average Output (kW)	674.8	
							Capacity Factor	82.34%	

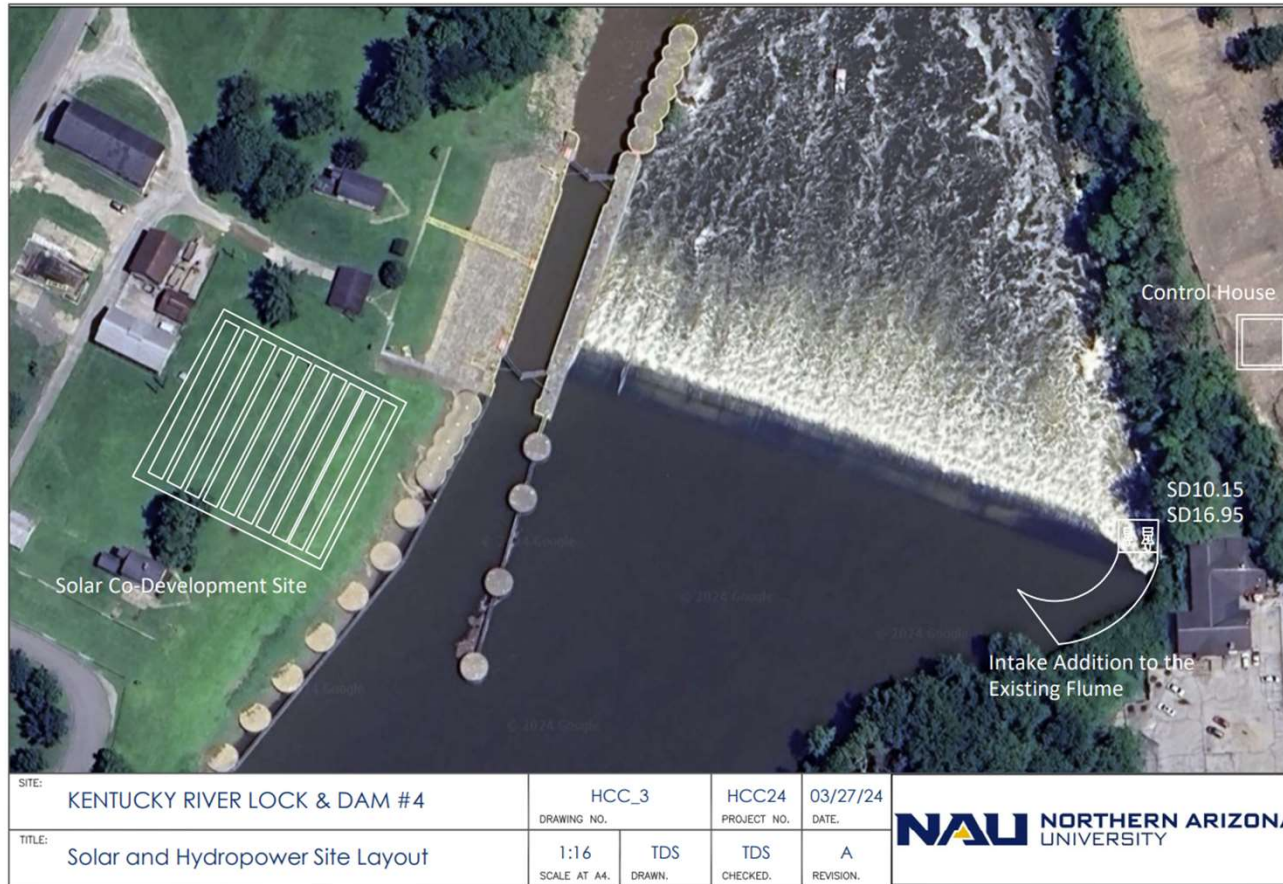
STREAMDIVER ANNUAL GENERATION

- Unit will shut off due to high flow rates and low heads
- **Capacity Factor:** Calculated using peak annual generation of 7,183.2 MWh
- **LCOE:** Calculated using SAM's fixed charged rate (FCR) method



Yearly Generation: Feb 1st - Jan 31st			
Year	Generation (MWh)	Average Output (MW)	Yearly Capacity Factor
2019-2020	3996.7	0.4561	55.64%
2020-2021	3847.1	0.4398	53.56%
2021-2022	3948.5	0.4563	54.97%
2022-2023	4842.2	0.5537	67.41%
2023-2024	5685.9	0.6486	79.16%
Average Capacity Factor:			62.15%
LCOE (from SAM)			42.40 ¢/kWh

SITE PLAN



SOLAR CO-DEVELOPMENT

- Next to the dam, we will install a 320-kW solar system. Based on PVWatts Calculator, the site has an estimated generation of about 1,338 kWh/Year.
- The solar panels are mounted at a 38-degree tilt, and the system will experience 14% in losses and has a capacity factor of 15.3%
- The cost will be roughly 350,000 for the system, and that does not include the 30% federal tax credit or other incentives specific to Kentucky.

PVWatts Calculator

RESULTS

1,338 kWh/Year*

System output may range from 1,265 to 1,394 kWh per year near this location

Month	Solar Radiation (kWh / m ² / day)	AC Energy (kWh)
January	3.34	90
February	3.88	91
March	4.29	109
April	4.97	118
May	5.23	126

June	5.66	128
July	5.48	127
August	5.56	131
September	5.45	125
October	4.77	118
November	3.85	97
December	2.93	78
Annual	4.62	1,338

System Capacity: 323.6 kWdc (2158 m2)



CAPITAL COST MODELING

Project Development Costs:	Current Prices
Obtain FERC License	\$ 200,000
Project cost incurred before closing	\$ 100,000
Cost of Additional FERC Work?	\$ 120,000
Final Design Engineering Work?	\$ 250,000
Development Fee	\$ 250,000
Land and Water Rights	\$ 32,000
Transmission Line Right of Way	\$ 18,500

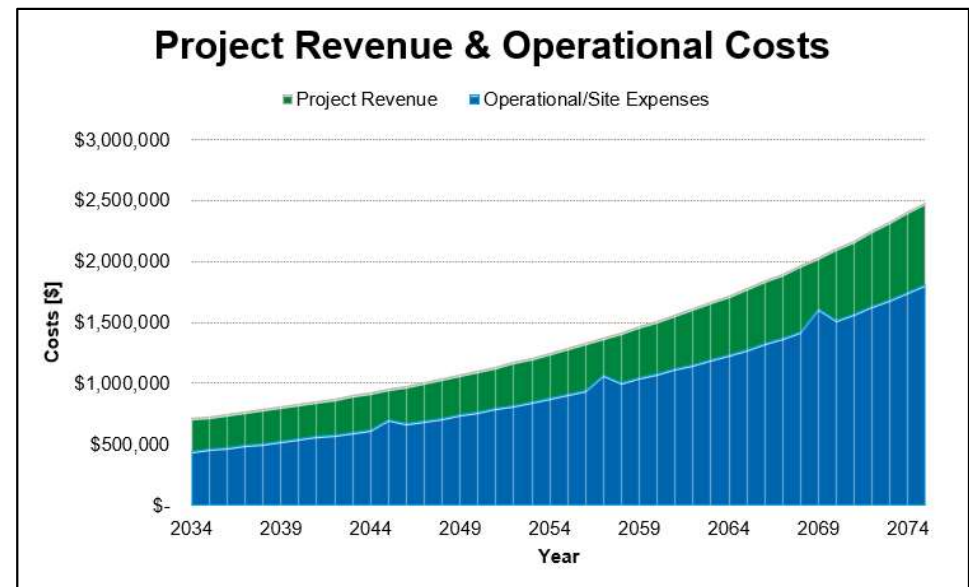
Plant Procurement and Construction Costs:	Current Prices
Site Preparation	\$ 150,000
Draft Tubes	\$ 800,000
Clear Silt from Dam?	\$ 400,000
Dewater Area of Development	\$ 700,000
Concrete Work?	\$ 500,000
Phase 1 Total:	\$ 2,550,000
Trash Rack and Frame	\$ 600,000
Turbines/Generators and Shutoff Gates	\$ 2,000,000
Switchgear	\$ 400,000
Log Boom	\$ 200,000
Control Building	\$ 430,760
Other Steel Components	\$ 250,000
Transformer/Station Main Breaker?	\$ 120,000
Low Voltage Transformers?	\$ 1,500,000
Electrical Cables	\$ -
Electrical Wiring	\$ 500,000
Solar Panels and Wiring	\$ 1,500,000
Backup Power System	\$ 120,000
Project Cost Subtotal	\$ 12,641,260

- Major Incentives:
 - RUS Loan for 40% of project cost
 - USDA REAP Grant: \$1,000,000
 - Renewable Energy Credits (next slide)
- Next Steps: Clarify civil construction costs with developers and ensure nothing is missing from construction scope

PROJECT REVENUE

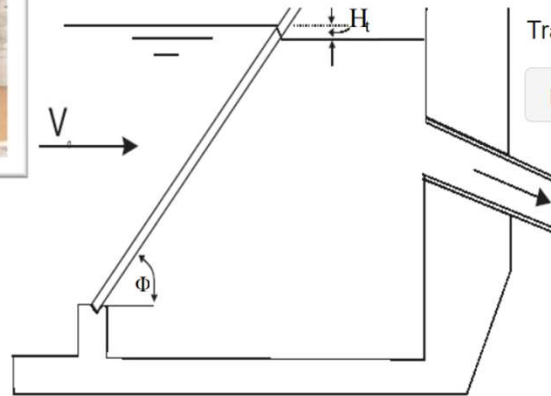
- Revenue Sales Rates: \$591,160/year
 - Power Sales Rate: \$72/MWh
 - REC Sales Rate: \$28/MWh
- Operational Costs: \$312.280/year
 - Yearly Property Tax: \$70,000
 - Yearly O&M: \$120,000
 - Yearly Liability Insurance: \$60,000
 - Voith Bearing Replacement: \$15,000 per unit every 12 years
 - Other: \$50,000

Confidence Interval Calculations		
Customers	Calculated Values	Inflation Percentage
Total	Avg	3.58%
	Sample Std Dev (s_x)	4.86%
	Std Dev of Means ($s_{\bar{x}}$)	0.69%
	Uncertainty (99% CI)	1.84%
	Uncertainty (95% CI)	1.38%
	Therefore: Inflation = 3.58% ± 1.38%	



TRASH RACK CALCULATIONS

- Trash racks prevent debris from entering the turbine intake. Filtering out debris maintains efficient turbine operation and reduces risk of clogging or damaging the StreamDiver turbine.
- Trash racks only cause minor head loss, in our case -0.103 mm head loss.



Trash Rack Calculation

```
k = 1; % bar shape
t = 19.05; % bar thickness [mm] (3/4 inch)
b = 101.6; % width between bars [mm] (4 inches)
Vo = 1; % approach velocity [m/s]
g = 9.81; % gravity [m^2/s]
theta = 30; % incline angle [degrees]
```

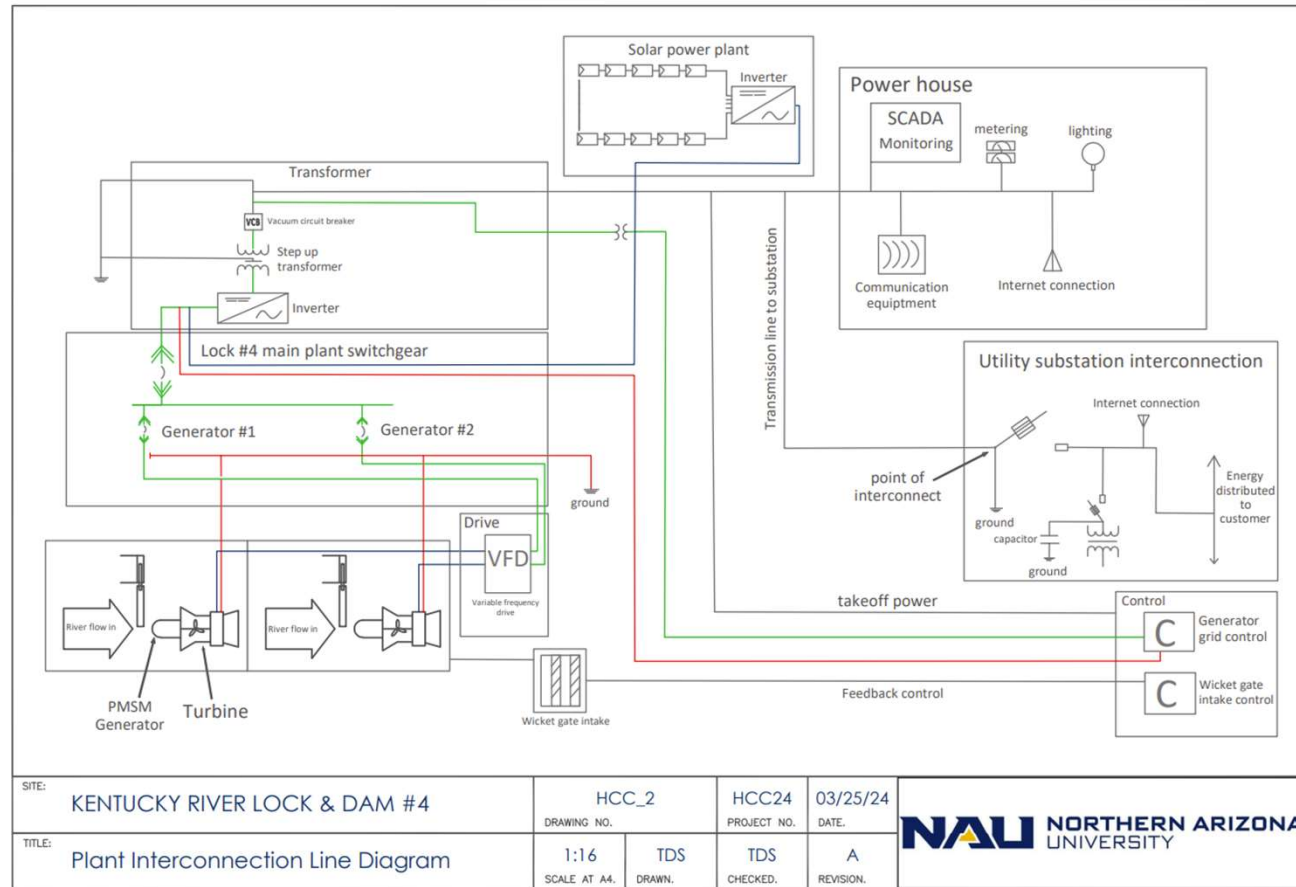
Trash rack head loss formula

```
Ht = k*t*((t/b)^(4/3))*((Vo^2)/(2*g))*sin(theta) % head loss (mm)
```

$$H_t = -0.1030$$

INTERCONNECTION/RELAY DIAGRAM

- Illustrates connections and interactions between electrical components.
- Provides detailed overview of the electrical infrastructure by following the flow of power through the system.

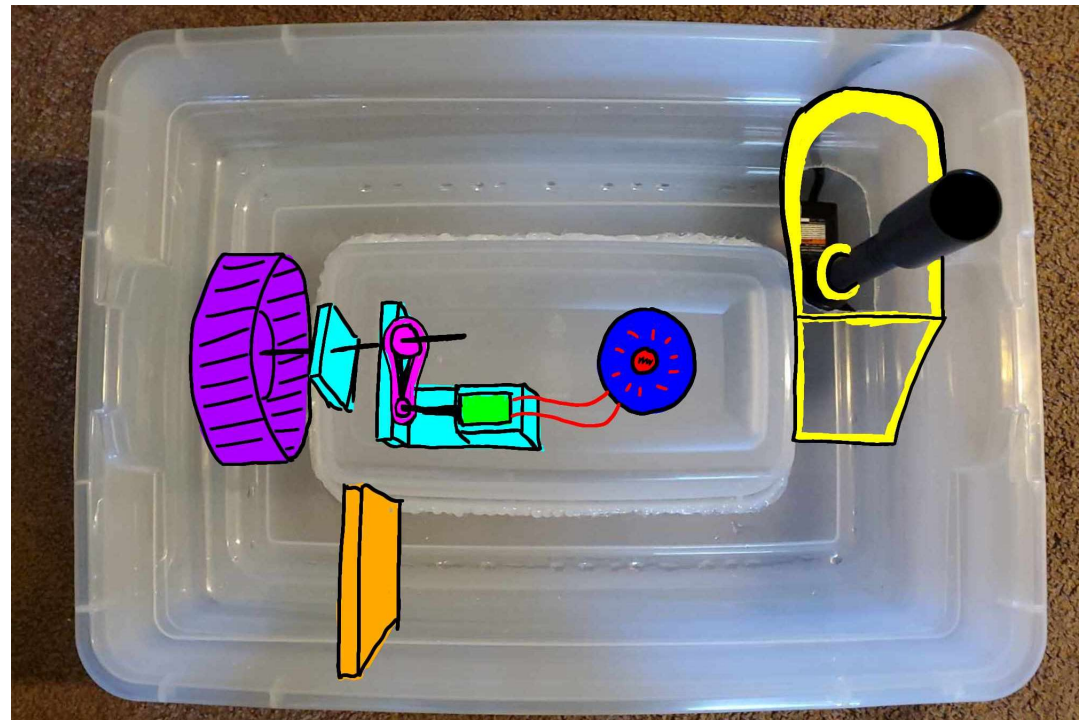


OUTREACH STREAM TABLE

- Pump Specifications – 620 GPH ~ 1050 mm³/s
- Water Wheel Diameter – 180 mm
- Motor Range Specifications -
 - 1.5 V, 5050 rpm, 56 oz-in ~ 395 N-mm
 - 3 V, 10100 rpm, 83 oz-in ~ 590 N-mm
- LED Specification – 1.5 V

$$\omega = \frac{Q}{A_x r} \rightarrow A_x r = \frac{Q}{\omega} = \frac{1050 \text{ mm}^3/\text{s}}{1000 \text{ rpm}} = 63 \text{ mm}^3$$

$$A_x r = 63 \text{ mm}^3 \rightarrow A_x = \frac{63 \text{ mm}^3}{90 \text{ mm}} = 0.70 \text{ mm}^2$$



PROJECT SCHEDULE

1	Week 10	03/25/24	10d	04/05/24	●	100%	Complete	
2	Continue drafting poster for competition	03/25/24	5d	03/29/24	●	100%	Complete	
	Replace with Testing Plan Deliverable	03/25/24	5d	03/29/24	●	100%	Complete	
2	Complete power modeling and operational modeling	03/25/24	5d	03/29/24	●	100%	Complete	
2	Hardware Status Update - 100% Build	04/01/24	5d	04/05/24	●	100%	Complete	
2	Complete Cost Model - Annual Generatoin	03/25/24	5d	03/29/24	●	100%	Complete	
1	Week 11	04/01/24	5d	04/05/24	●	0%	Not Started	
2	Confirm finishing touches with cost model	04/01/24	1d	04/01/24	●	0%	In Progress	
2	Complete solar modeling for co-development	04/01/24	1d	04/01/24	●	0%	In Progress	
2	Complete draft for competition poster	04/01/24	1d	04/01/24	●	0%	In Progress	
	Replace with Final CAD Deliverable	04/01/24	5d	04/05/24	●	0%	Not Started	
2	Team Photos and Video Submission (optional)	04/01/24	4d	04/04/24	●	0%	Not Started	
1	Week 12	04/08/24	6d	04/15/24	●	0%	Not Started	
2	Complete competition poster	04/08/24	5d	04/12/24	●	0%	Not Started	
2	Complete Siting and Design Reports	04/08/24	6d	04/15/24	●	0%	Not Started	
1	Week 13	04/15/24	6d	04/22/24	●	0%	Not Started	
2	Complete competition poster	04/15/24	5d	04/19/24	●	0%	Not Started	
2	Draft presentations	04/15/24	5d	04/19/24	●	0%	Not Started	
2	Complete Metrics Report	04/15/24	6d	04/22/24	●	0%	Not Started	
1	Week 14	04/22/24	5d	04/26/24	●	0%	Not Started	
2	Complete AND Rehearse Presentations	04/22/24	5d	04/26/24	●	0%	Not Started	
1	Week 15 - Competition in Iowa	04/29/24	5d	05/03/24	●	0%	Not Started	
2	Client Handoff - Spec Sheet and Operation/Assembly Manual?	04/29/24	5d	05/03/24	●	0%	Not Started	
2	WIN	04/29/24	3d	05/01/24	●	0%	Not Started	

THANK YOU!

NORTHERN ARIZONA  **UNIVERSITY.**